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THE COSMIC TAPESTRY: ARCHAEOASTRONOMY AND PLANETARIUMS AS EDUCATIONAL TOOLS

Sub-Theme: Diversity in Architecture

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ABSTRACT

Astronomy has played a crucial role in the development of early humans, from the times of classical civilizations such as ancient British, Greek and Egyptian settlements. The observations of the night sky, not only have influenced these cultures, but have also created landmarks in our world and over-shadow our modern understanding of astronomy. Archaeoastronomy is a simple branch of astronomical study, influencing architecture and archaeology. This interdisciplinary science aims to correlate the stars and the stones, connecting architecture, archaeology and astronomy. The architecture of the ancient city measured skies, serving as a profound tool that verified past observations while intricately linking the rich tapestry of the civilization's culture and science. Architectural structures have been conceptualized to depict the astronomical terms, governing the universe. The form, orientation, position and function of the celestial objects, enlightened people with the knowledge to understand and study astronomy. Spaces are created with the strategy to analyse the movement of sun, stars and planets. Presently, technology plays an important role in observing astronomical events, when combined with the curiosity of the human mind. This is the driving force, which motivates research, and also inspires us with its beauty and scientific analysis. This study aims to analyse the relation of architecture to astronomy, creating opportunities for future astronomical explorations.

Keywords: architecture, astronomy, archaeoastronomy, observations

1. INTRODUCTION

This research paper provides an overview of the research objectives, highlighting the significance of the integration of architecture and astronomy through celestial architecture. It establishes the context for understanding the historical development of planetariums and other celestial buildings, identifying their evolving role in society as powerful tools for astronomical exploration and education. Planetariums are architectural marvels that offer immersive and educational experiences, transporting visitors to the depths of the universe. Planetariums have transformed themselves into spaces, which inspire wonder and curiosity about the cosmos. These unique structures serve as astronomical theatres, combining the state-of-the-art projection systems, the architectural design and scientific storytelling to create awe inspiring celestial journeys.

The significance of archaeoastronomy reflects the beliefs, cultural and religious practices by incorporating astronomical alignments into their structures. It is served as the expression of their spiritual connection with cosmos and creating sacred spaces that were aligned with astronomical phenomena. The alignment of structures with specific stars or constellations have represented mythological figures or important deities. It has connections between the earthly realm and the celestial realm by reinforcing a culture's cosmological beliefs. It serves as a navigational aid, helping ancient mariners or travelers find their way by aligning their path with celestial objects. The assimilation of astronomy and architecture delivers a unique lens which to appreciate and safeguard our shared human history.

1.1. Aim

To provide a platform for observing and studying celestial events. learn how ancient civilizations used astronomical knowledge to design and build structures that are aligned with celestial events, for example temples, pyramids, observatories, calendars, etc.

1.2. Objective

Learn how ancient civilizations used astronomical knowledge to design and build structures that are aligned with celestial events, for example temples, pyramids, observatories, calendars, etc.

To understand the cultural significance of the sky and its occurrence for different societies in different time periods.

It helps to improve the science by providing new data, by taking sides on ancient astronomy and its history.

It helps us to redevelop the astronomical concepts and tests the theories about the origin and evolution of astronomy and its relation to other fields of knowledge.

We can delve into archaeoastronomy, starting our study, from ancient monuments like the stone-henges to modern observatories. This study looks into some iconic monuments, which explore the same principles. The Egyptian Pyramids, the Konark Sun Temple and Jantar Mantar in Jaipur, India are a few examples.

2. ASTRONOMY AND SACRED ARCHITECTURAL LANDSCAPES

Celestial events always fascinate humans, arising curiosity about our origin and the nature of our existence, with respect to the universe, the vastness of space, its form and orientation, movement and its extent. These events inspired settlements of the past generations, which have resulted in the initiation of certain architectural landscapes. Historical structures like Menhirs in France, Stone-henges in the Great Britain, Egytian pyramids in Giza, Jantar Mantar structures in Jaipur, Delhi, Ujjain, Varanasi and Mathura, Sun temples in Modhera and Konark, Gavi-Gangadareshwara temple in Bangalore, Mudumal in Telangana, Buzaham in Kashmir, Stone-circle in Junapani in Madhya Pradesh, etc. depicted the sacred landscapes, which have been constructed on the basis of certain principles, following the celestial events and movements. Most of this sacred architecture is constructed on the basis of the astronomical terms, which influence and govern the universe. Astronomy and architecture have been closely connected, since ancient times. Architectural advancements may not prioritize astronomical architecture, but probing, analyzing and strategizing these spaces may advance our understanding of this sacred architecture, and their influence in regulating architectural design.

2.1. Primary Astronomical Structures:

2.1.1. Jantar Mantar, Jaipur

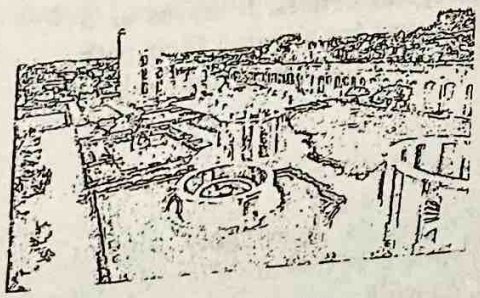


Figure 1. Jantar Mantar

Jantar Mantar, a collection of astronomical instruments, is an extraordinary observatory in Jaipur. It was constructed by Maharaja Sawai Jai Singh II in the early 18th century. It is UNESCO World Heritage site showcasing the king's passion for astronomy and his commitment to explore astronomical knowledge. The complex instruments within Jantar Mantar provide insights into the precise measurements and astronomical calculations employed by ancient Indian astronomers.

Jantar Mantar houses several large, fixed astronomical instruments, each serving a specific purpose. The instruments include the Samrat Yantra (Giant Sundial), Jai Prakash Yantra (Hemispherical Sundial), Ram Yantra (Giant Equatorial Sundial), and others. These instruments were used to measure precise astronomical measurements, for example, determining the time, declination and altitude of celestial bodies.

The Samrat Yantra is a massive sundial, which can measure time with accuracy. It can determine the local solar time, the time of the decline of the sun and can even measure the length of a single day. The design and orientation of the sundials emphasize the importance of solar observations in ancient Indian astronomy. The instruments are meticulously aligned with celestial objects and geometry of celestial movements, to determine the positions of celestial bodies, to calculate the heights and the azimuths of the stars and to study the movement of the sun and other celestial objects. The precise measurements and observations from Jantar Mantar contributed to the astronomical advancements and the development of Indian calendar systems.

2.2. Secondary Astronomical Structures:

2.2.1. Egyptian Pyramid complex at Giza:

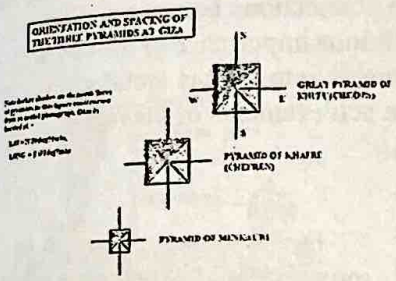


Figure 2.Egyptian Pyramids

The Egyptian pyramids, particularly the Great Pyramid complex of Giza, have long been associated with astronomical significance. There are several astronomical connections and theories related to the pyramids. The very concept of creating a sacred landscape of Giza reflecting the night sky, is a typical approach followed by different ancient cultures. Construction of pyramids, temples and tombs aligned with stars and the cardinal points, was to express the civilizations' respect for their Gods. The sides of the pyramids are precisely aligned with the cardinal directions, suggests a possible Egyptian astronomical inclination, to depict their keen interest in celestial bodies and their movements.

The Orion Correlation Theory proposes connect between the layout of the three pyramids at Giza and the stars in the Orion constellation. The three largest pyramids on the Giza Plateau (Khufu, Khafre and Menkaure) were built intentionally to demonstrate the relative positions of the stars in Orion's Belt.

The pyramids exhibit solar alignments, mainly during the equinoxes. For example, during the spring equinox, the sun aligns to the eastern face of the Great Sphinx, casting a shadow that moves along the path leading to the Sphinx. The pyramids astronomical connections are fascinating; it is important to note that the Egyptians motivations for construction were likely multidimensional. The pyramids served as tombs for the Pharaohs and were deeply intertwined with religious and funerary practices, with the alignment to celestial bodies potentially representing the Pharaoh's journey to the after-life and their association with the Gods.

2.2.2. Sun Temple, Konark:

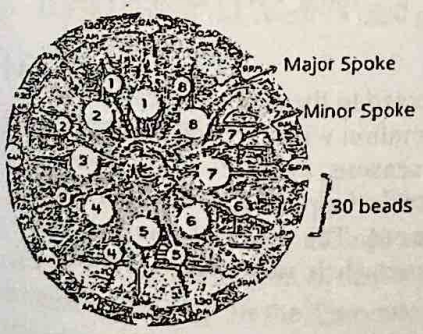


Figure 3. Sun Temple

The Konark Sun Temple, located in Odisha, India, is a masterpiece of medieval architecture. It is built in the 13th century, it pays service to the Sun God, Surya. The temple has unique chariot like design, decorated with complex stone carvings, which represents a fusion of art, science, and spirituality. Investigating the architectural features, astronomical alignments, and the cultural context surrounding the Konark Sun Temple helps us understand the historical and religious beliefs prevalent during the time of its construction. Sun Temple in Konark is designed in such a way that the main entrance of the temple faces east, towards the rising sun. This deliberate orientation suggests a connection with solar worship and the importance of the sun and its daily journey across the sky. The temple's architecture incorporates sundials or timekeeping devices. These sundials, known as "gnomon" or "shanku," are strategically placed on the temple walls and align with the movement of the sun. They were likely used to determine the time of day and mark important events or rituals based on the position of the sun.

In the summer and winter solstices, the sun rays align with certain parts of the temple, creating an interesting pattern of light and shadow on specific areas. The carvings and sculptures adorning the Sun Temple depict various celestial symbols, including celestial beings, celestial chariots and other astronomical motifs. These representations signify the sun and celestial bodies in ancient Indian cosmology and religious beliefs. The connections between the Sun Temple in Konark and astronomy showcase the cultural and religious importance of the sun in ancient Indian society and the integration of astronomical elements into temple architecture. The temple stands as a testament to the rich heritage and artistic achievements of the region.

2.2.3. Stone-henge

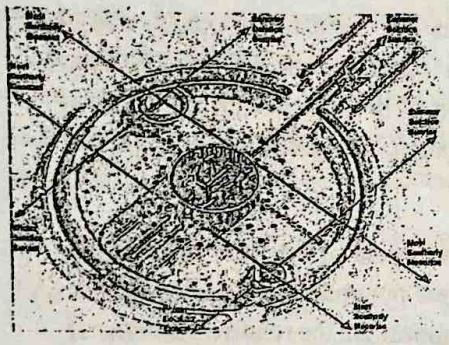


Figure 4.stonehenge

Stonehenge is the most iconic pre-historic archaeological monument in the world, which fascinates researchers, in the field of archaeoastronomy. It is located on Salisbury Plain in England. It consists of a circular arrangement of standing megaliths (large stones) from the Neolithic period, constructed between 3000 BCE and 2000 BCE. Its basic structure is a set of standing blue sarsen stones – trilithons, arranged in a circle that surrounds a horseshoe-shaped circle of stones. The basic circle originally had 30 standing stones, each topped by two lintels to form a continuous ring, at the top.

In the summer solstice, the position of the rising sun aligns with the Heel Stone, located outside the main stone circle, and casts a direct ray of light into the its centre. Similarly, in the winter solstice, the setting sun aligns with a specific avenue leading to Stonehenge. These alignments suggest that Stonehenge was used as an astronomical observatory or a ceremonial site to mark significant events in the annual solar calendar. The site's alignment with the moonrise and moonset during specific lunar cycles suggests that lunar observations were an integral part of the monument's purpose. The "Aubrey Holes," circular pits within the monument, have been associated with lunar observations, as they appear to track the lunar cycle known as the "Metonic cycle" (18.6 years long).

Stonehenge's astronomical alignments are believed to be connected to the cosmological beliefs and the religious practices of the people. The monument's association with celestial events was important with respect to their understanding of the changing seasons, agricultural cycles and the passage of time. Stonehenge's significance as a sacred site is supported by its ritualistic burials and the presence of artifacts found within the monument. The study of Stonehenge continues to contribute to our understanding of ancient cultures, their relationship with the cosmos and the also their engineering capabilities.

2.2.4. *Gavi Gangadhareshwara Temple, Bangalore*

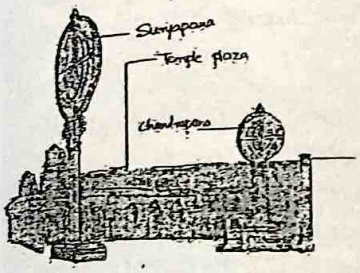
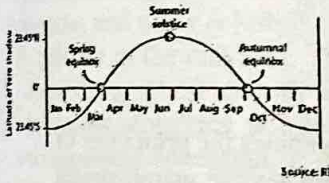


Figure 5. Gavi Gangadhareshwara temple



Source: RTUK.co.uk

Variation in latitude of zero shadow through the calendar year. Notice that every latitude between the tropics has two zero shadow days.

Figure 6

The Gavi Gangadhareshwara temple in Bangalore, is carved within a monolithic rock, creating a cave-like structure. It has a annual celestial event on 14 January. In this event, the rays of the setting sun illuminate the idol /deity inside the Gavi (cave). This phenomenon is said to symbolize the movement of the sun into the northern hemisphere. The temple has two discs in the front yard - Surya Pana and Candra Pana, which are identical in size with diameters of about 2m, and parallel to each other. The pillars supporting them pillar have beautifully engraved bulls in a sitting posture. The temple also showcases alignments related to equinoxes. During the equinoxes (around March 21st and September 21st each year), the sun rays pass through the main entrance of the temple, directly illuminating the deity inside. The temple's pillars and sculptures feature intricate carvings of various zodiac signs, emphasizing the connection between celestial bodies and human life. This reflects the ancient belief in astrology and the influence of celestial bodies on individuals. Their orientation appears puzzling because of several reasons:

- Such discs have not been seen in any other temple.
- The cross-hair-like engraving appears on either side of the disc.
- They are not aligned to the cardinal points.

The shadow of the western disc gradually moved towards the eastern disc.

2.3. *Indirect Relations*

2.3.1. *Vastu Shastra*

Vastu Shastra is an ancient Indian architectural system that encompasses principles and guidelines for designing buildings in harmony with natural and cosmic energies. It highlights the link between architecture and several aspects of human life, including health, wealth, and spiritual well-being. In the framework of Vastu Shastra, there exists an important connection between architecture and astronomy. This relationship is rooted in the belief that the positioning and alignment of structures should align with celestial bodies and their movements. Vastu Shastra places great importance on the orientation and alignment of buildings in relation to the cardinal directions and celestial bodies. The positioning of structures is believed to influence the flow of energy and facilitate a harmonious connection between the building and its surroundings. The directions are associated with the Sun, Moon, specific constellations and other celestial bodies. Aligning a building with these celestial bodies is considered auspicious and is believed to bring positive energy and prosperity to its inhabitants.

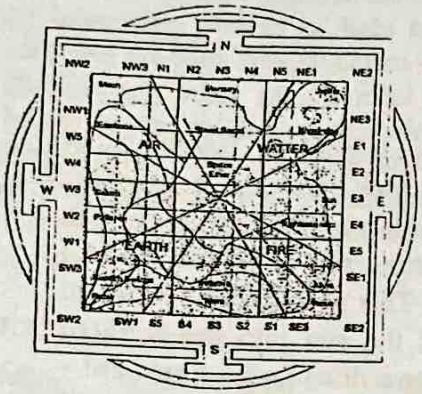


Figure 7. Vastu Shastra

The Nava-Grahas (9 planets) are the positions, where idols are placed in the Hindu temples, facing the cardinal directions, as per Vastu. The Sun (east facing) forms the center, Venus (east), Mercury (north-east), Jupiter (north), Ketu (northwest), Saturn (west), Rahu (south-west), Mars (South) and Moon (South-East) facing is based on the guidelines, defined in Vastu.

In the science of vastu, the concept of space is a dynamic element, in which all natural objects come into existence and disappear finally. The energy movement is through a particular rhythm or time measure, with the birth and development of all objects of nature and the causal element of all material forms. Vastu aims is to create harmonious and nature friendly building spaces. The inner space of an individual, vibrate in the same frequency or rhythm as the outer space in the cosmos.

3. MODERN ARCHAEOASTRONMY:

The Modern-day archaeoastronomy is a multidisciplinary field that combines the principles of archaeology, astronomy, anthropology and cultural studies. It investigates the astronomical knowledge and practices of ancient civilizations. This helps us to understand how ancient cultures are formed, interpreted, and utilized the Celestial phenomena, and their cosmological beliefs, cultural practices, and the intersection between astronomy and humans. By looking at the ancient structures, artifacts, and astronomical alignments, modern archaeoastronomy understands the logical and cultural heritage of past civilizations. The evolution of planetariums shows the advancements in technology, enabling more realistic, interactive, and fascinating experience to the visitors. From mechanical models to digital projectors, planetariums inspire and educate people about the marvels of cosmos. The modern planetarium, introduced in the early 20th century. The first planetarium projector, known as the star projector by the German engineer and optician Carl Zeiss. This optical device recreates a realistic representation of the night sky on a dome.

The start of digital technologies has modernized the planetariums. In 1990s, computer-controlled projectors swapped the analog systems, which allows more accurate and flexible presentations. Digital planetariums used high-resolution projectors, display images and videos on domes, permitting a great visual experience, Full dome video presentation allows exploration of not just the night sky but also a wide collection of scientific topics, for example astrophysics, biology, and geology. Modern planetariums include real-time data from astronomical observatories and space missions. This incorporation enables live presentations of current astronomical events and discoveries.

Planetariums expanded outside the visual displays to include other sensory elements. Setting a sound system creates a great audio experience, enhancing the visual content. Some of them also incorporate techniques like scent generators and seat vibrations to engage visitors and create a multi-sensory expedition.

3.1. Zeiss Planetarium

The world's first planetarium is the Zeiss Planetarium, located in Jena, Germany.

Figure 8, Zeiss Planetarium

Zeiss Planetarium was designed and built by the German engineer and optician, Carl Zeiss. This marked a breakthrough in the history of planetariums and transformed the way how people experience and learn about astronomy. This Planetarium had a ground-breaking star projector known as the Zeiss Mark I. This projector had advanced optics and projects accurate images of stars, planets, and other celestial objects onto the dome surface, by creating a realistic representation. The Planetarium provides star shows that allows visitors to explore the night sky in a virtual environment. Using the advanced projection systems, the planetarium restructures the celestial sphere with precision, shows the position and movements of stars, planets, and other celestial objects. The shows teach about constellations, sky objects and the dynamics of the universe. They present shows on the solar system, galaxies, black holes, and cosmology. These are designed to tell about complex astronomical concepts in a very accessible, engaging and in an interesting way. The Zeiss Planetarium serves as a hub for astronomical education. It offers a range of experiences and programs to inspire the public about the wonders of the universe. Through star shows, presentations, interactive exhibits, or educational outreach, the planetarium plays a vital role in developing curiosity and understanding of astronomy.

3.2. Birla Planetarium in Kolkata

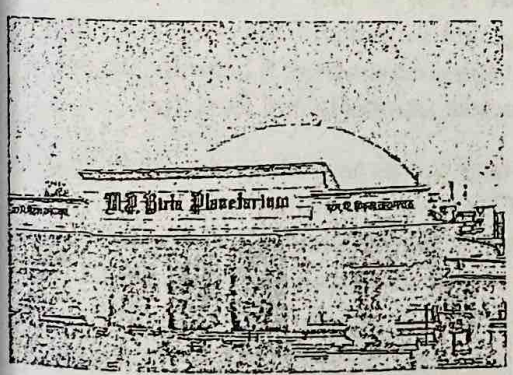


Figure 9. Birla Planetarium

The Birla Planetarium is located in Kolkata, it is one among the oldest and largest planetariums in India. The planetarium has sky shows, interactive exhibits, and educational programs. It has a rich history and dedication towards astronomical education. The planetarium allows us to explore the night sky in an imitated environment, by using the advanced projection systems. It shows the positions, movements, and characteristics of stars, planets, and other celestial objects. The sky shows offer insights into the beauty and complexity of the universe.

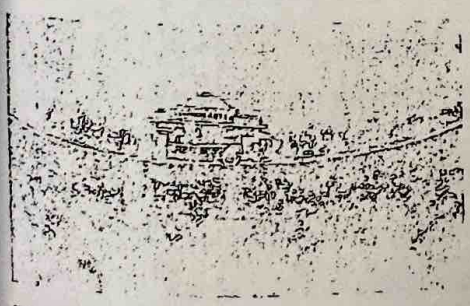


Figure 10. Dome Structure

The Birla Planetarium highlights the importance of astronomical phenomena and events. It conducts special shows and programs during events like eclipses, meteor showers, and planetary alignments, by providing opportunities to observe and learn about celestial events. The exhibits include models, displays, and multimedia presentations, illustrates the astronomical concepts, solar system, galaxies, and space exploration. They make us understand the importance of astronomical wonders.

The Birla Planetarium manages stargazing sessions, which allows visitors to observe celestial objects through telescopes. These sessions offer a practical experience of observing stars, planets, and other astronomical objects under the control of experts. The Birla Planetarium in Kolkata promotes astronomy and creates public awareness of this field.

	Timeline of ancient to contemporary astronomical structures
(c. 2560 BCE)	Pyramid of Giza
(c. 3000-2000 BCE)	Stonehenge
(c. 1724-1734 CE)	Jantar Mantar
(c. 16th century CE)	Gavi Gangadareshwara Temple
(c. 1675 CE)	Greenwich Observatory
(1888 CE)	Lick Observatory
(1935 CE)	Griffith Observatory
(20th century to present)	Modern Planetariums

4. CONCLUSION

This research paper helps us to understand the integration of architecture and astronomy has evolved over centuries, resulting in the creation of planetariums as powerful tools for astronomical exploration and education. The combination of archaeoastronomy and planetariums allows us to explore the human engagement with the night sky. By studying the astronomical practices of ancient civilizations, we can appreciate their scientific achievements, cultural beliefs, and their ability to navigate and make sense of their world. Meanwhile, planetariums serve as contemporary tools for learning and inspiration, fostering scientific literacy and sparking a lifelong interest in astronomy and space exploration. It helps to improve the science by providing new data, by taking sides on ancient astronomy and its history.

It helps us to redevelop the astronomical concepts and tests the theories about the origin and evolution of astronomy and its relation to other fields of knowledge. The architectural design, technological advancements, and educational significance of planetariums have transformed them into immersive spaces that inspire wonder and curiosity about the cosmos. By continually pushing the boundaries of technology and design, planetariums remain at the forefront of bringing the complexity of the universe closer to the public, enriching our understanding of the cosmos and igniting scientific curiosity.

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